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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Lubrication in the Steel Industry

Smelting and Refining

PUBLISHED MONTHLY BY
THE TEXAS COMPANY, U.S.A.
TEXACO PETROLEUM PRODUCTS

A Lesson from the Steel Industry

Industry in general might learn much from the Steel Industry.

In the first place it is a truism that the largest factor in the phenomenal success of the Steel Industry in America is due to the organization of equipment and machinery. In other words to the completely worked out interdependence of units and processes.

This is a good thing to keep in mind when considering the subject of lubrication.

The average layman, when he pictures the Steel Industry, thinks of noise and smoke, flying dust and enormous machinery.

This is true; but although much of the machinery used is ponderous it must not be thought that this machinery is "rough," nor that it can be operated without continuous supervision.

Continuous supervision is especially important because of the necessity at all times for continuity of motion.

One thing that promotes continuity of motion is correct lubrication.

The Steel mills have recognized this to such an extent that other industries can take example from the close attention accorded to lubrication.

Oils are carefully tested before being admitted to general use. Lubricants are checked as to consumption, and the means of distribution are nearly ideal. As a matter of fact few industries can show as substantial or as well cared for Oil-Houses as are generally found in Steel mills.

Therefore, we of The Texas Company are proud of the records being made by Texaco Lubricants in the Steel mills of this country. And we value the opportunity which has been given our Texaco Lubrication Engineers to cooperate with some of the leading mills in formulating lubrication practice.

The acceptance of Texaco Lubricants in this Industry is indeed a mark of merit and their continued favor is a proof of their ability to withstand the severest operating conditions of temperature, pressure, of scale and dirt, and continued use.

What we have learned in the Steel Industry is available to users of lubricants in all other industries.

What we are continually learning in our daily work in the Steel mills strengthens our ability to serve our clients and prospective clients in a manner which is making Texaco leadership more and more an accepted fact.

[There is a Texaco Lubricant for every purpose and they are being used on every kind and type of machine all over the world.]

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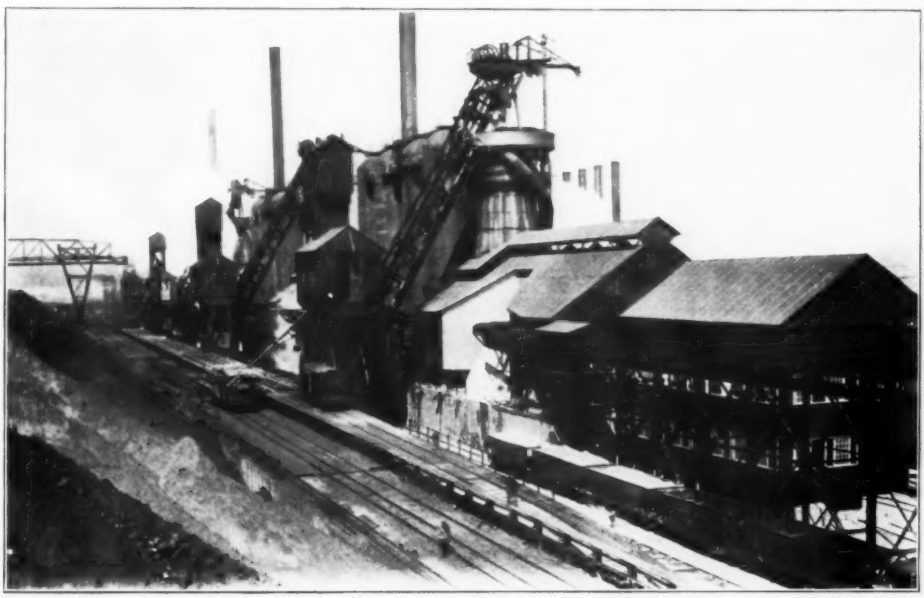


Courtesy of The Youngstown Sheet and Tube Co.

Fig. 1.—View of a blast furnace installation, showing ore pile in foreground, ore bridge, mixing platform, skip hoist and hot blast stoves.

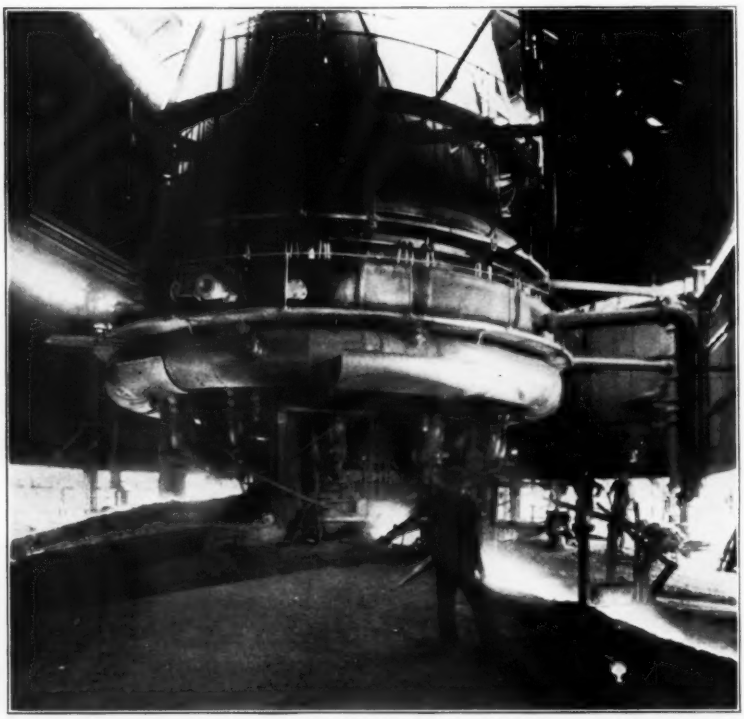
Lubrication in the Steel Industry

Smelting and Refining

WHILE the iron and steel industry may be said to trace its origin back to biblical times, when Tubal Cain discovered the possibility of working "black stones" into useful shapes by the combined effects of heat and hammering, essentially the invention of the Bessemer converter in 1856 marks the beginning of the age of steel. Iron, as such, figures prominently throughout the history of the world as the outstanding element in the advancement of civilization. That it should be early put to useful purposes by the ancients is probably attributed to the fact that as a component part of the earth's crust, its outcroppings presented a favorable substance for the exercise of their ingenuity.

Nor should we of the twentieth century lay full claim to its working into steel products.

The swords of Toledo and Damascus prove conclusively the skill of our forebears in the tempering of steel. But developments in civilization demanded developments in production. A Toledo blade was a masterpiece, just as a Toledo iron-worker was a veritable artist. The world, however, callously demanded volume; the beauty of the ages, wrought by hand over lengthy days of toil therefore gave way to the inventive genius of man. The blast furnace, the Bessemer converter, the open-hearth furnace and the rolling mill were the solution to our problems of maximum production with low cost and a minimum of labor. With this development, chemistry of iron and steel became a concrete science, to prove that by formulation of alloys with such elements as carbon, nickel chromium, vanadium and manganese, all manner of variable degrees of hardness, ductility and strength could be attained.



Courtesy of The Youngstown Sheet and Tube Co.

Fig. 2.—Base of a blast furnace showing blast tuyeres, metal trough and an attendant taking a sample button.

Chemistry and the ingenuity of the metallurgist, however, can determine only the nature of the product. They cannot govern the rate of production of the mechanical equipment involved because they have practically no control over that nemesis of mechanics—FRICTION. Therefore, the science of lubrication must be reckoned with. In fact, lubrication is the key to efficiency and production in the steel plant. The intensive operation demanded calls for a minimum of friction and uniformity of bearing temperatures in the face of the most discouraging operating conditions. Hot water, acid fumes, salt, dirt, dust, etc., are examples of the objectional factors confronting the lubricating engineer. Take a concrete example: Air compressor and blowing engine lubrication at best is a ticklish proposition; but a small amount of dirt or a short period of operation on the wrong compressor oil may give rise to dangerous conditions or often fires in the air lines; perhaps even explosions or ruptures will result. Can the steel man close down his blast furnace or his open hearth when these occur? He cannot, for if he did, the workings of perhaps the whole plant might be disrupted. So he fights the fire or makes his repairs on the run—or better still, uses a preventative in the form of lubricants which he can be reasonably sure will function properly and relieve him of as much worry as possible.

Numerous other examples could be cited wherein the importance of good lubrication is the outstanding feature. It is better, however, to reserve them for future discussion wherever they fit in. Suffice it to say, the details of wrought iron and steel mill lubrication are of vital interest to us all. An industry which consumes approximately 60,000,000 tons of iron ore per year evidently is based upon the last word in productive efficiency. In other words, the steel man has appreciated the value of scientific lubrication and lubricating engineering service.

In the smelting and refining of iron ores and scrap, for the purpose of converting them into workable grades of steel, there are three distinct phases of operation entailed, each involving its specific equipment. For example:

1. The process of smelting, which brings into usage such equipment as the blast furnace, etc.

2. The storage or mixing stage, wherein the mixer is involved, and
3. The process of refinement of iron into steel, involving either the Bessemer converter, the open hearth, or the electric furnace.

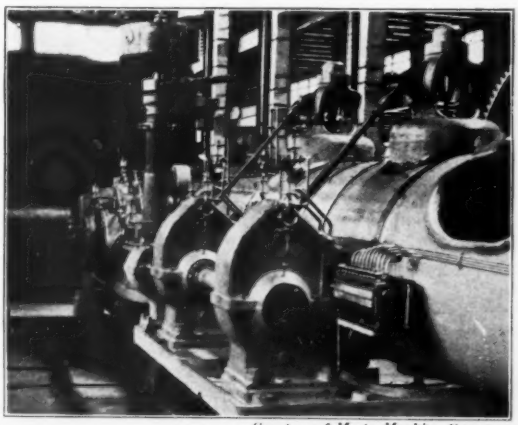
Due to the fact that the production of both wrought iron and steel involves much the same process machinery, a joint discussion is deemed advisable. In fact, considering the similarity which certain soft steels bear to wrought iron, it is often difficult to tell exactly where the dividing line occurs.

THE BLAST FURNACE

The first essential step in the steel plant is to reduce the iron ore as it is received from the mines, to a state of more or less pure iron, by means of the blast furnace. Iron ores are usually oxides of iron, in other words, combinations of iron and oxygen. The function of the blast furnace is to break up these elements by the combined effects of the burning of coke, and the chemical reaction which is brought about by means of a limestone flux. Thus the removal of silica and the formation of slag are effected.

A blast furnace consists of a vertical steel furnace or stack about eighty or ninety feet high and perhaps twenty feet in diameter, suitably lined with high refractory material such as fire brick. At the top is the charging opening through which measured quantities of ore, limestone flux, and fuel (coke) are charged periodically. At the bottom are two other openings, located one above the other but at some distance apart around the periphery of the furnace. The usual angle between them will be 60 degrees though 90 degrees may be found in some cases. The difference in the height or elevation of these openings varies with the size of the furnace. The upper (known as the Cinder Notch), serves for the removal of slag or waste products, resulting from the de-oxidation or reduction of the iron ore; the lower (commonly called the Iron Notch), serves for tapping or pouring of molten iron. In general, iron is drawn off at four-hour intervals, about one hundred tons being obtained each time.

Before charging can be done, the ore must be transferred from the ore yard to the storage bins by means of an unloading car or an overhead traveling crane. From here the various grades of ore, according to the type of pig iron desired, are in turn charged into a transfer car in measured quantities. This car travels on a track located parallel with the blast furnaces so that it can be made to serve any of their respective mixing bins as necessary. Further mixing is attained by delivery of the contents of the transfer car to the mixing bin. The charge is then ready for delivery to the electric lorry cars and subsequently to the skip hoist. This latter device runs on an inclined plane extending from the base of the mixing bins to the top of the blast furnace. Tracks are laid on this incline up which the skip hoist buckets are drawn to the top of the furnace by wire



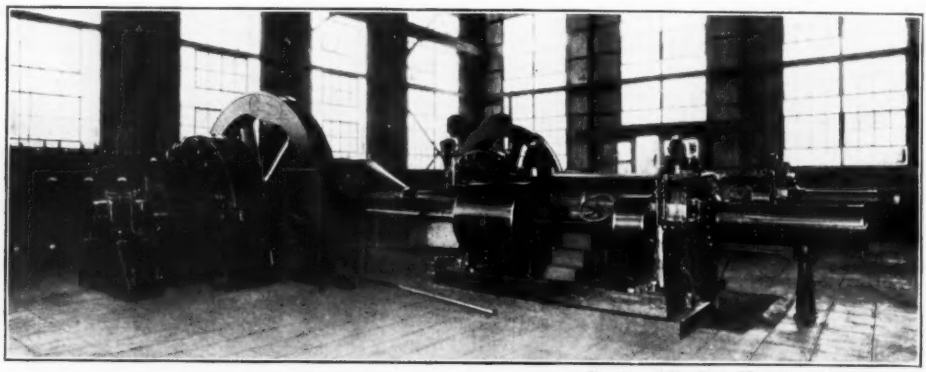
Courtesy of Mesta Machine Company.

Fig. 3.—A Blowing Engine Steam Cylinder of the Una-flow type. Note extensive lubricating equipment and sight feed devices installed. It is oftentimes a difficult problem to effectively lubricate large engines of this type, and careful attention must be given to both the lubricant and lubricating equipment.

ropes. Usually a skip will hold from three to four tons of ore or limestone and about half as much coke. Some buckets discharge by automatically turning over, others through a trip-operated hopper in the bottom like a modern gondola coal car. Charging is an important factor, in that uniformly successive layers of ore, flux and fuel are necessary to promote even melting and descending of the charge. In order to prevent the escape of any furnace gas the charging opening at the top of the blast furnace is equipped with two cones or bells, one located above the other. As the contents of the skip fall upon the upper or little bell, it is lowered, the material dropping to the top of the big bell below. When the little bell is again closed the big bell is allowed to drop, the charge sliding down into the furnace below. Thus, after a blast furnace is once started, it can be kept running over an indefinite length of time, often for many months or even years, until the lining or some other part becomes so worn or damaged as to require renewal, or poor business or accidents are met with. In other words, there is no time when it can be said that charging is complete, and the furnace never cools down to any great extent while it is running.

The necessary blast of hot air which has been pre-heated by passage through hot blast stoves is introduced into the furnace near the

bottom through ports known as tuyeres. This permits the coke to burn, the resultant heat bringing about the necessary reaction between the flux, ore, and carbon monoxide gas. During the smelting process, iron separates from the impurities or slag, settling to the bottom of the furnace. As this reaction progresses, after about every four hours, the molten iron is tapped or drawn from the furnace, being allowed to either flow through a series of troughs into suitable moulds or sand beds to form what are known as pigs, or being drawn directly into ladles mounted on trucks, for the purpose of perhaps storage in the mixer, or immediate conversion into steel. The slag as formed is run into pits or ladles, granulated with water and hauled to the slag dump; it plays no further part in the production of either wrought iron or steel. It is, however, extensively used in the cement industry. When each pour is completed, the tapping holes or notches are plugged by means of a "clay gun" or steam actuated plunger device, which automatically drives balls of soft clay into the openings. During this operation, the blast is shut off, the material in the furnace settling somewhat as a consequence.



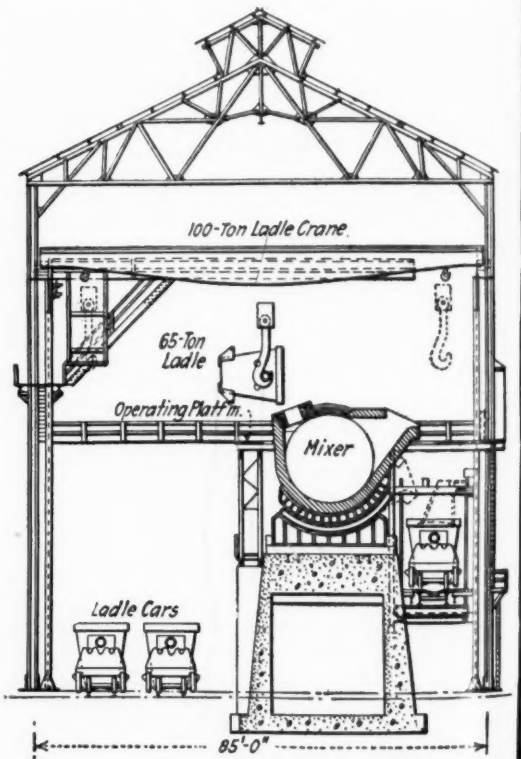
Courtesy of Nordberg Manufacturing Company.

Fig. 4.—A Uniflow engine installation used as the driving element for electric generators. The furnishing of electric current to the steel mill is a decidedly important feature, and the positive operation demanded calls for the most careful attention to lubrication.

Lubrication of Blast Furnace Equipment.

Blast furnace operation involves the use of considerable mechanical apparatus. For example, there are the huge steam reciprocating or turbo-blowing engines which furnish the necessary low pressure blasts of air to the hot-blast stoves for pre-heating prior to delivery to the blast furnaces; the charging equipment which includes the wire ropes and bearings of the charging lorries and skip hoists, with their respective driving engines or motors, the slag cranes, the steam or hydraulic clay guns, the ladle cars and any miscellaneous gearing installed.

While the range of equipment is varied, the lubricating problems are not numerous. The blast furnace generates high heats and these are naturally radiated to their surroundings quite considerably. It is perfectly possible, however, to locate much of the necessary mechanical equipment either permanently or otherwise, so that it will be both free from this



Courtesy of The Iron Age, and Weirton Steel Co.

Fig. 5.—Sectional view of a Mixer Installation, showing ladle car on scales at the right on a level with the charging floor of the open hearth. Note also the overhead ladle crane used for pouring molten iron into the mixer.

heat and also not subject to excessive dirt or dust. Take the case of blower steam cylinders for example: If they are lubricated with a good grade of cylinder oil which has been compounded and refined to meet the requirements of steam and operating conditions, perfect satisfaction should be attained. Bearings in turn can be grouped into two classifications:

1. As involving automatic lubricators, or
2. Exposed, hand-oiled conditions.

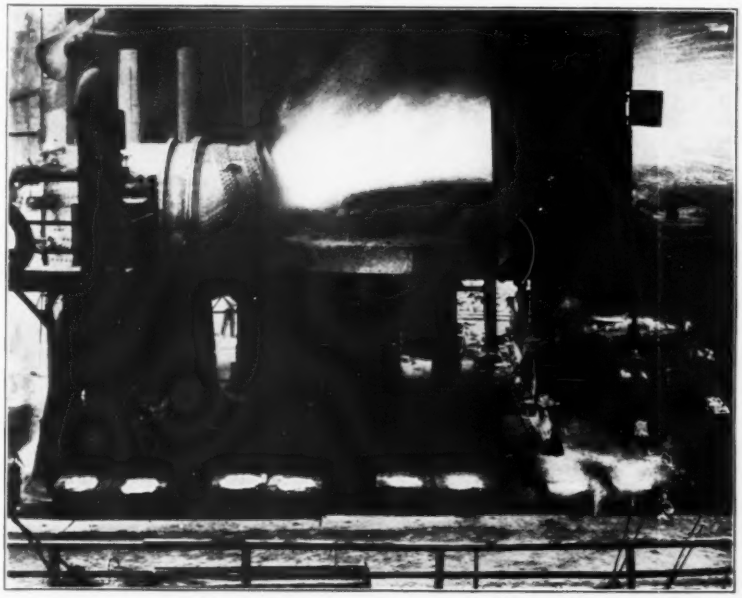
Steam engine, pump, turbo-blower, and electric motor bearings are largely oiled by some automatic system of lubrication. Inasmuch as they are usually enclosed systems and not subjected to external heat, they should give little or no trouble. Exposed, hand-oiled bearings as are found on skip buckets and transfer cars, etc., receive rougher service, and dust, dirt, and rain are always detrimental factors. Such bearings have high clearances, however, and operate at low speeds and pressures, therefore, a rough lubricant such as black oil is found to serve very well.

Gears and wire rope operate under similar conditions to skip car journal bearings, though at perhaps higher working pressures. Therefore, a lubricant must be used which will not drip from their surfaces, which will penetrate to the core of the ropes, and which will adhere tenaciously to the gear teeth in an even film. Usually a straight mineral gear and rope compound of from 1000 to 2000 seconds viscosity Saybolt at 210 degrees F. will satisfy these requirements.

Air tub lubrication is exceedingly important due to the fact that pressure must be kept on the lines to the blast furnaces and Bessemer converts, etc., at all times. Therefore, cleaning is practically impossible, and the blowing cylinder lubricant must be so refined as to give rise to minimum carbonaceous accumulations in the air system as far as possible. Furthermore, every care should be observed to insure against feeding oil in excessive quantities to the air cylinders. In fact the right kind of oil will lubricate most satisfactorily when a minimum amount is fed to the cylinders. Excess never improves lubrication and only leads to objectionable oil deposits. The subject of air compressor lubrication and the effects of deposits were treated in considerable detail in LUBRICATION for March, 1924. Air tub pressures in the steel plant are usually low (in the neighborhood of 15 to 20 pounds), and temperatures will therefore never run much above 300 degrees F.

THE MIXER

When pig iron is to be kept molten after it has been poured from the blast furnace, preparatory to charging into the converters or open hearth, it is poured into a firebrick-lined ladle which is mounted on a suitable car and transported to the mixer. This latter is simply a large receptacle of several hundred tons capacity which serves to keep the iron in molten state, to uniformly mix the products of perhaps several blast furnaces and to desulphurize the metal to a certain extent. While the mixer usually does not heat the iron, it must always, however, be prepared to do so if necessary. Therefore heating equipment of some sort is essential, depending in extent upon the nature of the fuel at hand. Gas is very satisfactory for this purpose when available. Even where no extra heat is supplied, we can appreciate that the mixer will naturally radiate consider-



Courtesy of The Youngstown Sheet and Tube Co.

Fig. 6.—Starting a blow in the Bessemer Converter. The ladle and ingot moulds full of hot metal can be seen in the foreground. Excessive heat and the prevalence of dust, dirt, hot metal and slag are ruinous to any but the best grades of lubricants. Therefore gears and bearings require heat resisting, adhesive lubricants which will insure operation with a minimum of friction and a maximum of production.

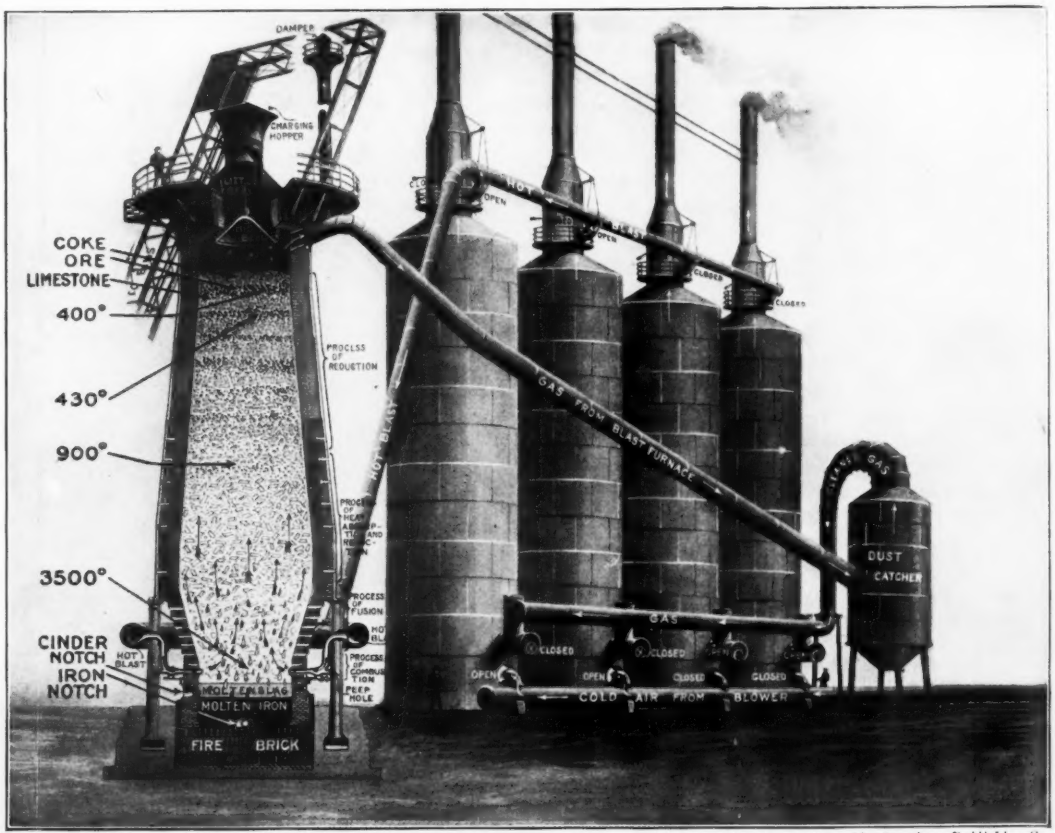


Fig. 7 *Courtesy of Scientific American Publishing Co.*

A TYPICAL MODERN BLAST FURNACE INSTALLATION

"Typical Blast Furnace: Height, 90 feet; diameter about 25 feet. Makes 550 tons of iron every 24 hours. Built of steel like a huge upright steam boiler and lined with fire brick, the lower portion which is hottest being surrounded with hollow bronze bricks filled with rapidly flowing water. The blast passes up through 1500 tons of load, which is arranged in alternate layers of ore, coke and limestone, skilfully put in at the top so as to be loose and porous enough to allow free passage of the blast which rushes up about as fast in one second as the load melts and sinks in one hour.

As the load sinks to 400 degrees of heat, the chemical action of the uprushing blast of gas removes 90 per cent of the oxygen in the ore and transforms the ore into a finely divided sponge of iron particles that remain in this shape all the way down to the process of fusion.

Sinking to 430 degrees of heat, the sponge begins to take on great quantities of the glowing carbon from the coke, amounting to several times its own volume, but an opposing chemical action sweeps the carbon away; again it returns. This chemical battle keeps up until the load sinks to 900 degrees of heat, when the carbon in the iron sponge ceases to increase.

From the 900 degrees point downward to the process of fusion the iron sponge with its dissolved carbon passes, and the illustration shows it melting into drops of iron together with the drops of slag—which is the union of the siliceous residue of the ore and limestone and the ashes of the coke—all trickling down through the mass of incandescent coke at 3500 degrees of heat. The slag floats on top; the iron on the bottom.

The slag is drawn off frequently at the cinder notch, while the iron is drawn from the iron notch every four hours, yielding about 100 tons of pig iron at a draw and taking about 15 minutes to run out. The blast is stopped to replug the notch and it is then that the whole mass of material in the furnace, relieved of the supporting influence of the upward blast, slightly sinks."—*Scientific American, April, 1924.*

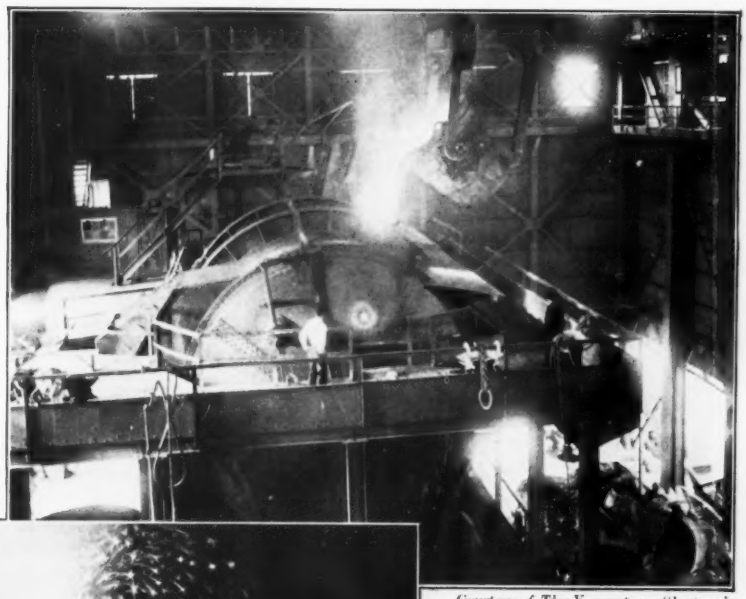
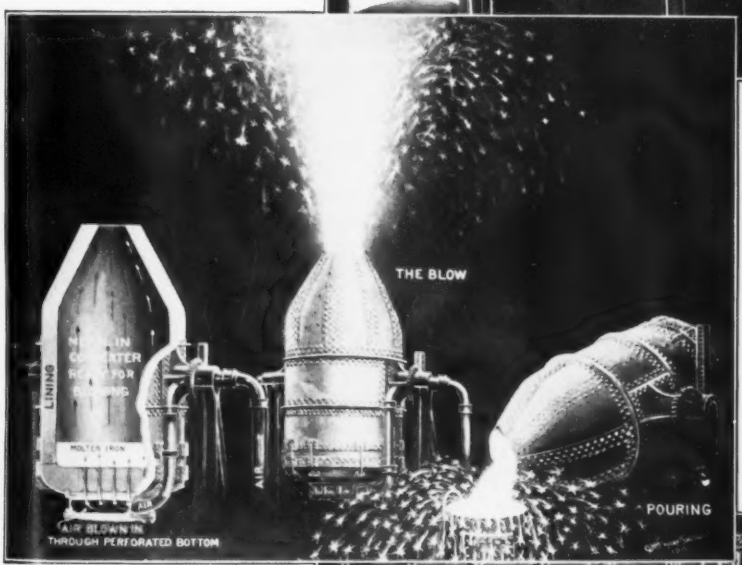


Fig. 8.—Pouring Molten Iron into the Mixer. Note the heat rising and enveloping the crane mechanisms which serve to tip the ladle—a severe condition which the lubricant must meet.

Courtesy of The Youngstown Sheet and Tube Company



Courtesy of Scientific American Publishing Co.

Fig. 9.—Details of construction and operation of the Bessemer Converter. The rack and gear mechanism which serves for tipping can be plainly noted.

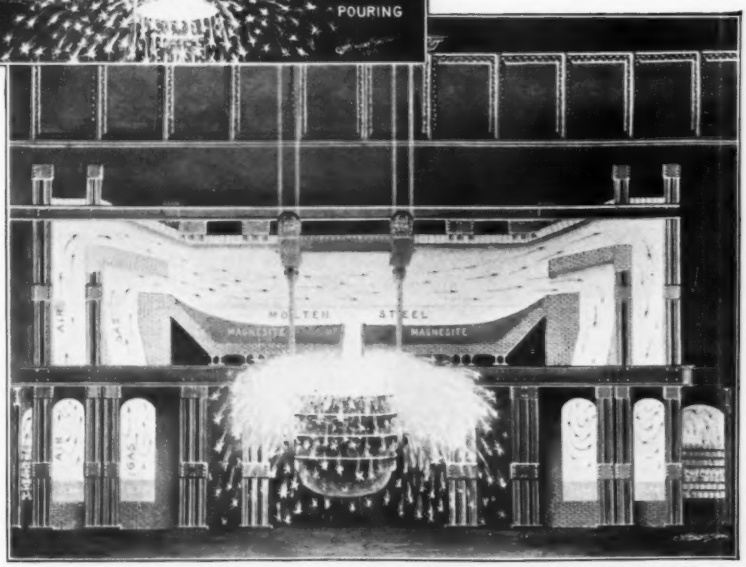


Fig. 10.—The Open Hearth Furnace, showing the construction and arrangement of the various parts. Molten Steel is periodically tapped into the ladle shown in the center foreground, which is carried by an overhead travelling crane.

Courtesy of Scientific American Publishing Co.

able heat to its surroundings. Furthermore, it imposes a severe load on its rollers and tipping mechanisms when it is rotated for emptying its contents into the ladle cars.

These devices, therefore, require careful attention to lubrication, for bearing and gear lubricants must withstand heat, pressure, dust and contamination by flying sparks. A straight mineral lubricant of from 1000 to 5,000 seconds viscosity Saybolt at 210 degrees F., according to weather and temperature conditions has been found best suited for this service. Bearings are usually hand lubricated with the exception of ring-oiled motor bearings; to meet the rough conditions involved

Courtesy of The Youngstown Sheet and Tube Company

Fig. 11.—Charging molten metal into the Open Hearth. The crane which carries and tips the enormous ladle used for this purpose, must be given special attention as to lubrication, for it must function in perfect harmony; otherwise serious consequences might result.

black oil is generally used. Motor bearings, however, require a good grade of medium viscosity engine oil.

From the mixers the iron is transported to the Bessemer converter, the open hearth or electric furnace. The Bessemer converter was the original equipment used for the purification of iron, though the open hearth followed closely, being commercialized in about 1864. While both serve the desired purpose, the open hearth has supplanted the Bessemer whenever steel alloys of exacting chemical characteristics are to be produced. The electric furnace in turn is proving even more advantageous than the open hearth, although it has not come into general commercial usage as yet.

BESSEMER CONVERTERS

The Bessemer converter is a circular steel shell, built much in the shape of a barrel. Within this shell is a lining of refractory brick and clay ranging from perhaps 12 to 18 inches in thickness. This serves as protection for the shell as well as a heat insulator. The bottom of the converter is closed, the top or neck being left open for pouring and the discharge of waste gases, etc., during the process of blowing. In size, the Bessemer converter will vary somewhat; usually, however, it will not be above 20 feet in height nor 16 feet in inside diameter. In the bottom or base of the converter are located the tuyeres or perforations through which the necessary air is blown into the charge during the blow. It is the oxidizing action of this air which burns away the silica, carbon and other elements originally contained in the charge of pig and scrap iron. While the burning off of each of these elements has a characteristic flame and is recognizable by the steel worker, it is the oxidation of carbon which really indicates the extent of completion of the blow by the shower of sparks which shoot from the mouth of the converter at this stage of the process. When all the impurities have been burned off, the blow is stopped, the converter turned and such elements are added as are necessary to give the resultant steel the necessary characteristics. The metal is then poured into a ladle, after which it is ready for casting as ingots.

Converters of this type normally hang in a vertical position, being mounted at the center upon trunnions which permit tipping for the purpose of charging and pouring. For this reason the air connections which are generally made through one of the trunnions, must be flexible to a certain extent in order that the converter may be blown in any position. The initial charge, whatever its nature, must be molten. Some plants therefore take the product directly from their blast furnaces or mixers; others use cold pig iron, melting it in cupolas before charging. After sufficient molten metal has been charged, however, solid pigs or scrap iron may be dropped in without damage to the lining since they will become instantly plastic and soon melted, due to the heat of the molten charge. Immediately after charging, as the converter is tipped upright, the air blast must be started.

Lubrication.

The fierce heat adjacent to the Bessemer converter naturally gives rise to considerable skepticism when it comes to lubrication. In fact, in the vernacular, "no can do!" has been the contention of not a few steel workers. But the converter has to operate, and be free to swing readily when charging or pouring is done, therefore the operating mechanism which comprises a pair of hydraulic plungers with suitable racks and pinions adjacent to the trunnions, must work with the least possible friction, otherwise the power consumption and time of turning might be rapidly increased. These gear mechanisms as well as the plungers are subject to very high conducted heat. Therefore the lubricant must be heat resisting to the highest degree. A straight mineral product of high viscosity has been found to meet the converter's requirements satisfactorily, due to its adhesive characteristics.

The blast for the blowing of Bessemer converters may be supplied by either horizontal or vertical steam blowers or turbo-blowers. These normally are located in engine rooms apart from the converters, and their lubrication, involving circulating oiling systems or mechanical force feed lubricators, is similar to that of any power plant unit, with no serious problems to worry about. See LUBRICATION for November, 1923, and March, 1924.

From the converters the steel is poured into a ladle which is usually carried by a steel crane capable of swinging on a vertical axis, for transfer to the ingot moulds. Cranes of this type are gear-operated. The predominance of heat, slag and steel dust naturally imposes the same severe requirements upon the lubricant as elsewhere in this part of the plant; as a result lubrication of gears and bearings often become quite a serious problem. If the gear compound as recommended for converter gears is used, with a good black oil for bearings and journals, many of the lubricating difficulties will be eliminated. In other words, the lubricant must resist heat and contamination with foreign impurities.

Ingot and ladle cars may be equipped with either plain journal boxes and brasses, or roller bearings. The latter are coming into quite extensive usage due to their savings in oiling labor, inspection and lubricants. While it might seem that such bearings would be subjected to considerable heat, we must remember that inasmuch as they are practically always in the open air, radiation can occur unhampered. As a result, such bearings, even before the ingots have solidified, will be comfortable to the touch. Hot metal, slag, dust, dirt and variable loads are usually the more important factors which must be considered. Especially are the former detrimental to plain journal bearings of the railway type because of the rough service and careless handling which is prevalent. In fact journal box covers either ajar, open or broken off, is a common occurrence. In the roller bearing of course, the housing is tight and no carelessness can so disarrange it as to expose the bearing or lubricant to the detrimental action of hot iron, slag, dust, dirt or water.

OPEN HEARTH FURNACES

Certain grades of pig iron and scrap, however, cannot be properly worked in a Bessemer converter, especially since such detrimental elements as sulphur and phosphorus are increased as the process continues. The basic open hearth furnace removes these elements more completely, though sulphur to a rather limited extent; in fact, there is considerable difficulty attached to the removal of sulphur even in this manner. Fortunately, however, only when it is present disproportionate amounts will it be necessary to make an especial effort to reduce it in the open hearth. In general, steels of definite properties can be produced as stated above.

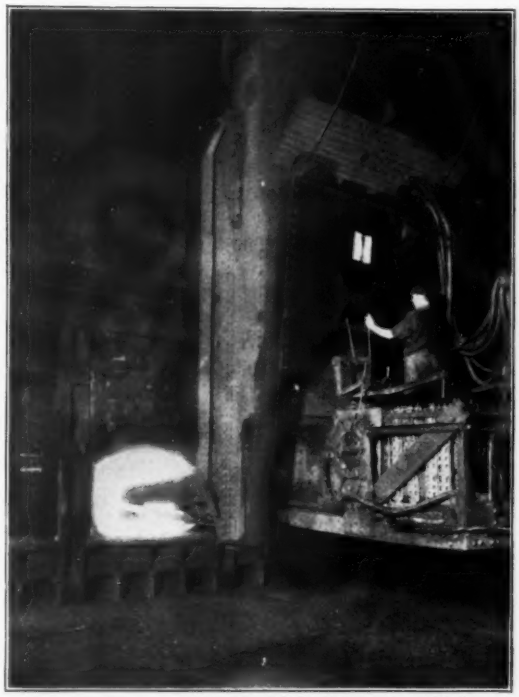


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Fig. 12.—The Charging Crane of an Open Hearth in operation. This crane is used for charging solid metal such as scrap. It also is subject to intense heat conditions, as can be noted, thereby imposing a severe requirement upon its lubricants.

In the open hearth furnace the necessary heat for melting and refining of the iron is obtained from producer gas, fuel oil or natural gas. Fuel oil is coming to be quite an important factor in such plants as have limited gas equipment. Producer gas is usually developed adjacent to the furnaces in a producer gas plant. Iron is charged both in solid and molten condition. Scrap of any sort usually is loaded into charging boxes carried on suitable cars, and dumped into furnaces by means of an electrically operated charging crane. The usual order of charging such a furnace is to spread a layer of limestone over the bottom, load in the scrap, heat it to a moderate temperature, pour in the molten pig iron from a ladle via a suitable trough. All these steps are rendered mechanical by use of the electric charging crane and an industrial railway system.

The charging doors are then closed and firing is started to render the entire charge molten. During the "heat" samples or "buttons" must be periodically taken for chemical analysis or observation, to determine how refinement is proceeding. In general, the melter's skill and experience in reading from a fractured sample, the characteristics of the metal in the bath is all that is necessary; analysis before tapping only being made when extremely rigid specifications have to be met. In fact, the art of steel making is patterned on the way Mother used to judge when her bread and cakes were "done." When the desired grade of steel is indicated, the charge is poured into a brick-lined ladle, of sufficient size to hold the entire output of one furnace "heat." The tapping hole is generally located on the opposite side of the furnace from the charging doors, near the bottom. The ladle is usually built with a bottom outlet, so that it can in turn be tapped and its contents run into ingot moulds, just as is done in the Bessemer plant. This is the process of casting steel. These moulds are mounted on suitable ingot cars, the journals of which are often equipped with roller bearings. A complete "pour" from an average open hearth furnace will make perhaps thirty ingots.

Pouring ingots from either the open hearth or Bessemer converter requires care and skill in order to insure uniformity of metallic structure throughout. The wrong temperature in fact, will often render an ingot unsuitable for rolling due to the formation of cavities brought about by uneven heating and retention of gases.

Courtesy of The Youngstown Sheet and Tube Co.

Fig. 13.—Pouring Steel from the Open Hearth into ladle cars.

Ingots must be allowed to remain in their moulds for a sufficient length of time to insure solidification. They are then "stripped" or removed by means of an electrical stripper. This device consists of a pair of jaws within which is a suitable plunger. The entire mechanism is crane operated, ingot cars being run underneath, and the stripper moved from one to the other. Each ingot in succession is removed by gripping the mould with the jaws, the plunger meanwhile bearing against the top of the ingot. The jaws and mould are then raised, the plunger holding the ingot down on the car.

Lubrication.

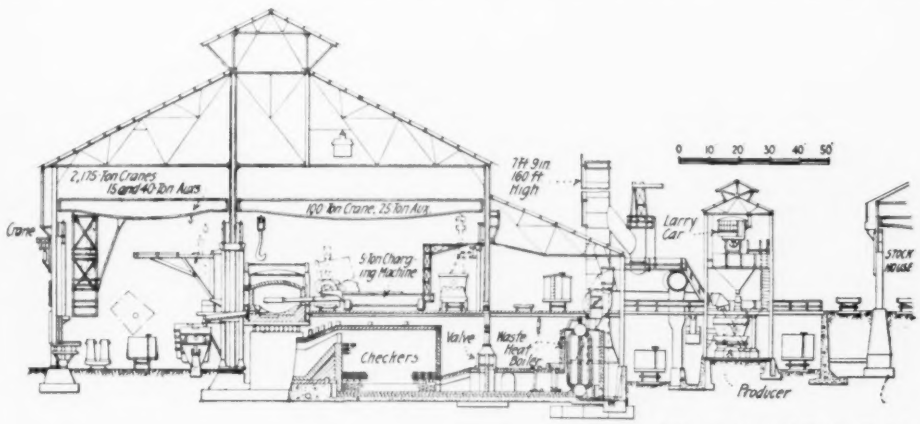
In the open hearth plant there is relatively little machinery requiring lubrication except the charging cranes, overhead traveling cranes, strippers, and operating mechanisms for raising

and lowering the charging doors. In general, all equipment in this part of the plant which must be lubricated will be electrically operated. The overhead traveling cranes which serve for the handling of metal ladles are the most important hoisting devices involved; their uniqueness lies in their high rating, some running up to 200 tons capacity. All have at least two separate hoists, the smaller or auxiliary being oftentimes as powerful as in the average crane found on other work. As in the Bessemer plant, heat and contamination are the chief detriments to which the lubricants are subject. The cables, gears, bearings, hoists and trolleys of all these mechanisms are periodically exposed to the extreme heat of molten metal and hot gases which arise from the boiling steel during tapping. This is particularly applicable to the cables holding the hooks which raise the ladles. As a result, lubricants which are not specially refined will tend to dry up and lose their effectiveness rapidly.

In certain plants where induced draft fans are installed to force the hot gases from the open hearth through a series of waste heat boilers, the lubrication of the bearings of these fans will often become difficult due to the heat from the hot gases which is conducted by the shaft to the bearing. These fans are usually motor driven, being equipped with water-cooled, ring-oiled bearings. To properly meet the heat conditions and afford the necessary lubrication, a relatively high viscosity engine oil, or even, in some cases, a steam refined cylinder stock must be used.

THE ELECTRIC FURNACE

While the open hearth furnace is remarkable for the accuracy with which it turns out steels of practically any desired characteristics, even better products are said to be obtainable through the use of the electric furnace and the adaptation of the electric arc. Essentially, the electric furnace consists of a bowl-shaped steel shell of from 4 to 8 feet in diameter (or even larger in some cases), suitably lined with firebrick or other refractory material. To the bottom is attached a toothed rocker which meshes with a rack. Thus the furnace can be tilted for pouring, by setting in motion the operating motor which manipulates the furnace through a connecting rod and a reduction gear. The lining of the electric furnace is a very important feature, just as it is in the Bessemer converter and open hearth. Usually three layers of several inches each of different refractories are used. Through the roof or dome, which is also heavily constructed of refractory brick, projects the carbon electrodes.



Courtesy of The Iron Age and Weirton Steel Co.

Fig. 14.—Sectional view of the open hearth showing the mould yard at the left, the pouring pit, charging floor, producer house, charging machine, ladle cars and overhead cranes.

These transmit the necessary electric current to the charge of molten iron, limestone and other necessary ingredients which must be used to reduce the iron oxides and remove sulphur and phosphorus. Later on, elements such as nickel, chromium, manganese or vanadium, are added in measured quantities according to the grade of steel and the nature of the alloy which is desired. The passage of electric current through the charge in the furnace brings about temperatures as high as 3000 degrees F. during the process of refinement. The extent to which such temperatures can be controlled is one of the outstanding advantages of the electric furnace. In general it will require from four to five hours per heat, in such a furnace, in contrast to the Bessemer which takes about 15 minutes and the open hearth which may require perhaps 6 to 12 hours to do the same work.

Lubrication.

The usual mechanisms which will require lubrication in the electric furnace are the rack

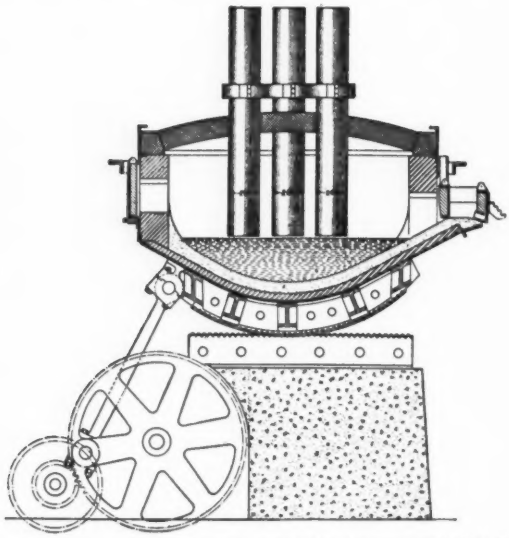


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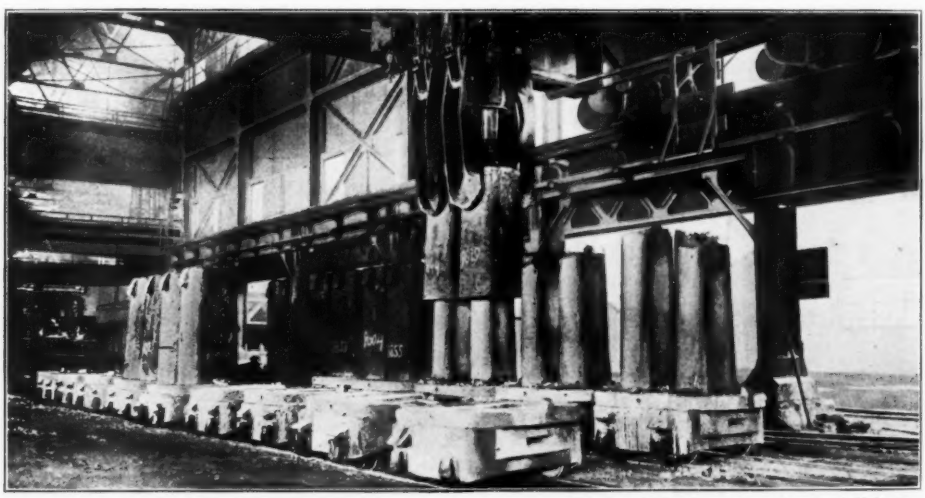
Fig. 15.—Section through an electric furnace showing the bath of molten metal, three electrodes, the tipping rack below the furnace and the motor driven crank which puts this into motion.

and gear teeth, the bearings of the operating motor and connecting rod and any other accessory journals involved. In general, heat conditions will not be quite as severe, nor will these mechanisms be subject to as dusty operation as elsewhere in the mill. Therefore the usual lubricants specified heretofore for similar mechanisms will function with perfect satisfaction, in fact, lasting longer and giving better service than when operating conditions and temperatures are more severe.

CONCLUSION

Although we have but given a fleeting introduction into the smelting and refining branches of the steel industry, we feel that sufficient has been said to bring out the particularly important part which is played by lubrication. To be true, the average equipment is rough, and massive, and first glance would lead one to believe that lubrication was really but a trifle. But the operating mechanism of these massive units must be accurately designed and machined, since they are so inter-dependent upon one another. In effect, the principles of good machine-work must be incorporated in the steel mill as everywhere else in industry, if efficient production is to result.

Therefore, with such a condition at hand lubrication of moving or rubbing parts becomes of the most vital importance, for in company with the usual problems of pressures and clearances, we have heat, dust and dirt to contend with in their most aggravating form. These facts will be even more evidently brought out in later articles which will discuss lubrication in the steel rolling mill, and in the mining and handling of iron ore.



Courtesy of The Youngstown Sheet and Tube Co.

Fig. 16.—Stripping ingots after pouring and solidification in the ingot moulds. The stripper jaws or nippers can be plainly seen drawing moulds off the ingots. These are actuated from above by a traveling crane.

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